Development of High-Fidelity Material Response Modeling for Resin-Infused Woven Thermal Protection Systems

Completed Technology Project (2016 - 2020)

Project Introduction

For future space exploration missions, it is essential for the thermal protection system (TPS) found on hypersonic vehicles or atmospheric entry probes to be well-designed in order to ensure mission safety. TPS materials can be classified as either ablative (e.g., ablators such as the Phenolic Impregnated Carbon Ablator, or PICA, used on Stardust) or non-ablative (e.g., reusable materials such as ceramic tiles used on the Space Shuttle). The former class is typically used in extreme entry conditions and the latter in milder environments. The proposed work seeks to use computational modeling techniques to provide essential tools to assist in the design of ablative TPS. In particular, the proposed work plan intends to develop a high-fidelity modeling framework for the new promising family of ablators, woven TPS (WTPS), a class of TPS known for its diversity and flexibility in design. The proposed modeling is divided into two main components: (i) coupled computational fluid dynamics-surface chemistry modeling of the gas-surface interaction in the vicinity of the TPS surface with inclusion of finite rate surface chemistry effects, (ii) high-fidelity material response modeling of the WTPS material. Emphasis is placed on the latter as high-fidelity modeling of woven systems is unprecedented. Both a macroscopic and microscopic level of analysis is proposed to study the multiscale aspects of WTPS. The proposed work will target modeling of WTPS for the Adaptive Deployable Entry Placement Technology (ADEPT) system due to the availability of high-quality experimental results from progressive arc jet testing. This will allow for an excellent validation campaign for the model developed. The products of the proposed research will be pivotal in guiding the design and sizing of WTPS for future NASA missions and experiments. This will be critical in transforming NASA missions and advancing the Nation's capabilities by maturing crosscutting and innovative space technologies. The proposed modeling effort is aligned with the goals of NASA's Entry Systems Modeling project under the Space Technology Mission Directorate and is of highly relevant interest to the entry systems modeling group at the NASA ARC.

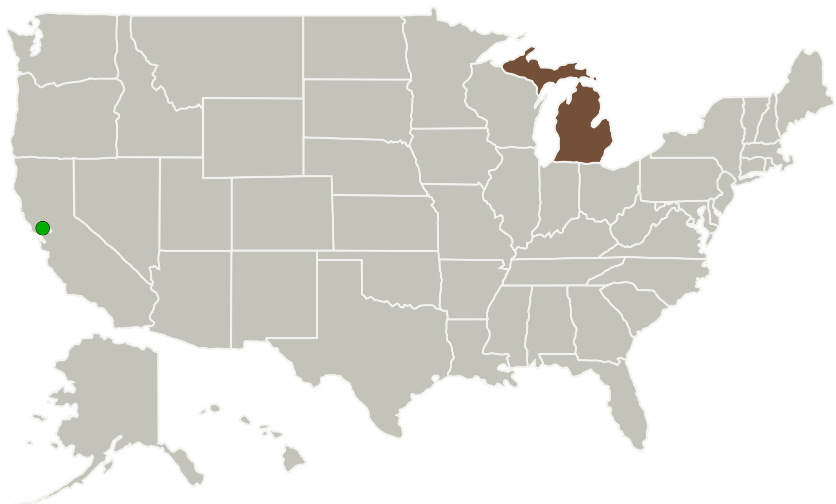
Anticipated Benefits

The products of the proposed research will be pivotal in guiding the design and sizing of WTPS for future NASA missions and experiments. This will be critical in transforming NASA missions and advancing the Nation's capabilities by maturing crosscutting and innovative space technologies.

Development of High-Fidelity Material Response Modeling for Resin-Infused Woven Thermal Protection Systems

Table of Contents

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
University of Michigan-Ann Arbor	Lead Organization	Academia	Ann Arbor, Michigan
Ames Research Center(ARC)	Supporting Organization	NASA Center	Moffett Field, California

Primary U.S. Work Locations
Michigan

Project Website:

https://www.nasa.gov/strg#.VQb6T0jJzyE

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

University of Michigan-Ann Arbor

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

Anthony Waas

Co-Investigator:

David Zhenzhong Dang

Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **3**

1	2	3	4	5	6	7	8	9
Applied Research			Development			Demo & Test		

Technology Areas

Primary:

- TX09 Entry, Descent, and Landing
  └ TX09.4 Vehicle Systems
    └ TX09.4.5 Modeling and Simulation for EDL

Target Destinations

Earth, Mars, Others Inside the Solar System